

# Revenue Forecasting Methodologies

---

# Single Exponential Smoothing

---

$$F_t = F_{t-1} + \alpha(y_{t-1} - F_{t-1})$$

- $F_t$  is the forecast revenue for period t
- t is the time period
- $\alpha$  is the smoothing constant,  $0 < \alpha \leq 1$ 
  - We set this coefficient by using solver to find the value that results in the lowest Mean Squared Error
- $y_{t-1}$  is the previous period's actual revenue
- $F_{t-1}$  is the previous period's forecast revenue
  - We set the value for the first forecast as equal to the previous month's actual

This method is generally best for short-term forecasts

- Because after actual values are no longer available, the last available forecast is used as the value for all future forecasts

# 12-Month Moving Average

---

To make a 12-month moving average forecast, we take the average of the last 12 actual or forecast values

$$F_t = \text{Average}(y_{t-12}:y_{t-1})$$

- $F_t$  is the forecast revenue for period  $t$
- $t$  is the time period
- $y_{t-12}$  is the actual revenue for the time period 12 periods before  $t$
- $y_{t-1}$  is the actual revenue for the time period immediately before  $t$

$$F_t = \text{Average}(y_{t-12}:F_{t-1})$$

- $F_{t-1}$  is the forecast revenue for the time period immediately before  $t$

$$F_t = \text{Average}(F_{t-12}:F_{t-1})$$

- $F_{t-12}$  is the forecast revenue for the time period 12 periods before  $t$

This method is best for relatively short-term forecasts, as the forecast values flatten after we reach 24 months beyond the last actual value

# Simple Trending

---

This method treats the data as linear, and uses linear regression to determine the average slope of the data over time

$$F_t = m * t + b$$

- $F_t$  is the forecast for period  $t$
- $t$  is the time period
- $m$  is the slope
  - To find this, use the SLOPE function in excel, with actuals as y-values and  $t$  as x-values
- $b$  is the intercept
  - To find this, use the INTERCEPT function in excel, with actuals as y-values and  $t$  as x-values

This method allows us to make forecasts far into the future, but is limited because it does not account for seasonal fluctuation

# Time Series Regression

---

This is the most sophisticated methodology used in our forecasting

We use a centered moving average to divide the data into a de-seasonalized component and a seasonal factor for each month

- Then we apply linear regression to the de-seasonalized component to identify the trend
- Then we re-apply the monthly seasonal component to the de-seasonalized trend

This method allows us to forecast more long-term, and takes seasonality into account

# Time Series Regression-Formulas

---

12-month moving average:  $MA_t = average(y_{t-5}:y_{t+6})$

- $MA_t$  is the moving average for period  $t$
- $t$  is the time period
- $y_{t-5}$  is the actual value for the time period 5 periods before  $t$
- $y_{t+6}$  is the actual value for the time period 6 periods after  $t$

Centered moving average:  $CMA_t = average(MA_t:MA_{t+1})$

- $CMA_t$  is the Centered Moving Average for period  $t$

Extracting seasonality and irregularity:  $S_t, I_t = y_t/CMA_t$

- $S_t, I_t$  is the seasonal and irregularity component for period  $t$

Extracting just seasonality:  $S_t = average(all\ S_{tmonth}, I_{tmonth})$

- $S_t$  is the seasonal component for period  $t$
- $S_{tmonth}, I_{tmonth}$  is the seasonal irregular component for all time periods that occur during the same month of the year. For example, to find the seasonal component for December, average the  $S_t, I_t$  for all Decembers. Then, use this averaged value as the seasonal value for each December

# Time Series Regression-Formulas

---

De-seasonalizing the data:  $DeseasonalizedY_t = Y_t/S_t$

- $DeseasonalizedY_t$  is the deseasonalized value for period t

Finding the trend component:  $T_t = m * t + b$

- $T_t$  is the trend component for period t
- $m$  is the slope
  - To find this, use the SLOPE function in excel, with  $DeseasonalizedY_t$  as y-values, and t as x-values
- $b$  is the intercept
  - To find this, use the INTERCEPT function in excel, with  $DeseasonalizedY_t$  as y-values, and t as x-values

Making the forecast:  $F_t = T_t * S_t$

- $F_t$  is the forecast for period t

# Compound Annual Growth Rate

---

Compound Annual Growth Rate (CAGR) allows us to find the annual rate of growth over a given time period, and use this to create annual forecasts

$$CAGR = \left(\frac{EV}{BV}\right)^{\frac{1}{t}} - 1$$

- $EV$  is the ending value for your time period (for our forecasts, the last available actual)
- $BV$  is the beginning value for your time period
- $t$  is the number of years covered by your time period

$$F_t = CAGR * F_{t-1}$$

- $F_t$  is the forecast for period  $t$
- $F_{t-1}$  is the forecast (or actual) for the previous time period



# Modified Compound Annual Growth Rate

---

Several modified CAGR methods were created during the time of COVID-19

This method aims to forecast recovery from COVID-19, and the associated social distancing policies

- Phased social distancing is necessary during COVID-19 outbreaks to contain the spread of the virus, but these policies mean substantial reductions in several revenue sources and potential long-term increases in unemployment

## 3-Year CAGR

- Assumes permanent downward shift in demand
- Compound annual growth rate is applied to 2021 budget value

## 3-Year CAGR 2019 Base

- Assumes full recovery in 2022
- 2022 estimate is greater than the 2019 estimate by the compound annual growth rate, as though 2020 and 2021 did not happen

## 3-Year CAGR 2019 Base Ramp Up

- Assumes gradual recovery until 2025
- Combination of 3-Year CAGR and 3-Year CAGR 2019 Base

# 3-Year CAGR 2019 Base Ramp Up

---

$$F_{2022} = (CAGR * F_{2021}) + (((CAGR * Y_{2019}) - (CAGR * F_{2021})) * .5)$$

- $F_{2022}$  is the forecast for 2022
- $CAGR$  is the compound annual growth rate, calculated as shown on the compound annual growth rate slide above
- $F_{2021}$  is the 2021 estimate being used
- $Y_{2019}$  is the 2019 actual

$$F_{2023} = (CAGR * 2 * F_{2021}) + (((CAGR * 2 * Y_{2019}) - (CAGR * 2 * F_{2021})) * .66)$$

$$F_{2024} = (CAGR * 3 * F_{2021}) + (((CAGR * 3 * Y_{2019}) - (CAGR * 3 * F_{2021})) * .85)$$

$$F_{2025} = (CAGR * 4 * F_{2021}) + ((CAGR * 4 * Y_{2019}) - (CAGR * 4 * F_{2021}))$$

# R Regression

---

More complex linear regressions are completed using the statistical software R

- This provides more processing power than Excel

This method is similar to the “simple trending” method described previously, but it takes into account seasonality and economic variation, in addition to the trend over time

$$F_t = a + b * t + c * e + m_i$$

- $F_t$  is the forecast for period  $t$
- $a$  is the intercept
- $b$  is the coefficient for time, and  $t$  is the time period
- $c$  is the coefficient for the economic indicator, and  $e$  is the value of the economic indicator
  - This economic indicator will be the unemployment rate, GDP, etc
  - Up to three economic indicators could be included
- $m_i$  is the coefficient for month
  - There are 12  $m_i$  values, one for each month. Select the one corresponding to the appropriate month.
- The best values for  $a, b, c, m_i$  calculated by an automated computer program since the math is too complex to conduct in excel

Model fit can be evaluated using an R-squared value, which represents the percentage of variation in revenue that can be explained by the equation

# Gross Domestic Product (GDP)

---

The GDP methodology makes the assumption that many revenue streams will grow or decline at a similar rate to the US economy in the long run. Under this methodology, we start with the 2021 budget value and grow a given revenue at the same rate as forecasted GDP growth.

Firstly, numerous US GDP growth rate forecasts from reputable sources were collected. Both the most conservative forecast, and the average of all forecasts, were used. Real GDP is adjusted for inflation to represent actual output changes independent of price changes. This is appropriate for quantity-based taxes (e.g. Gasoline Tax of 6 cents per gallon). However, percentage-based tax revenue (e.g. Sales Tax of 1.75%) will grow with price increases, so nominal GDP is more appropriate.

$$F_t = F_{t-1} * (1 + GDP_t)$$

- $F_t$  is the forecast for period t
- $F_{t-1}$  is the forecast (or actual) for the previous time period
- $GDP_t$  is the predicted GDP growth rate in period t, either real or nominal depending on the revenue

# Example: Sales Tax

